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By Scott Sanford

Choosing the Best **Biomass Heating Option**

Long term energy prices are expected to continue to rise. Investing in biomass energy should be a good investment if biomass is readily available in your area.

An increasing number of growers are looking at biomass heating. Here are some biomass heating options for a 30- by 96-foot freestanding greenhouse used to produce spring bedding plants.

Spring bedding plant production

A gothic style greenhouse, located near Madison, Wis., measures 30 feet wide by 96 feet long and 13 feet tall. It has a 3-foot tall side wall. It is covered with a double layer of polyethylene film on the roof and sides and 8 mm double-wall polycarbonate sheet on the end walls.

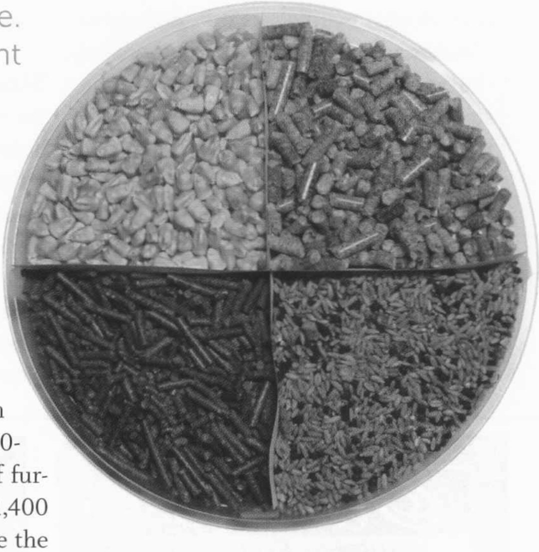
The house is used from Feb. 1 through June for growing bedding plants and vegetable transplants with an average set-point temperature of 70°F days and 60°F nights. The heating system is two propane-fired 200,000 Btu per hour power-vented unit heaters (78 percent efficiency). The propane is budgeted at a cost of $2 per gallon.

Option A: Install a residential/shop pellet stove to supplement the heating. The pellet stove has a rated output of up to 70,000 Btu per hour and would operate mainly at night. The unit would be set near an end wall and would rely on existing circulating fans to move the heated air throughout the greenhouse. The unit does not have a thermostat control so the grower has to estimate the heat setting based on the forecasted temperature for the evening.

The installed cost is estimated at $4,350 (the stove costs $3,500, chimney pipe costs $550, labor and brick pad cost $300). The stove has an expected efficiency of 80 percent.

Option B: Install a thermostatically-controlled pellet furnace with a heating capacity range of 10,000-160,000 Btu per hour. This type of furnace has a high volume blower (1,400 cubic feet per minute) to distribute the heated air. A short section of duct would be attached to the outlet to direct the air horizontally down the greenhouse. The furnace would be placed at one end of the greenhouse near one of the existing unit heaters.

The installed cost of the furnace is $6,030 which includes the furnace, a fuel bin that holds 14 bushels, thermostat control, chimney, brick pad and labor. A bulk storage bin for pellets could be installed in the future to reduce the fuel cost and handling. For this study, bagged fuels will be used. This furnace has an expected efficiency of 80 percent. The boiler controller automatically ramps up and down the output allowing it to be used during periods of lower heat demand.



Biomass heating fuel sources can include (clockwise) corn (top left), wood pellets, small grains and prairie grass pellets.

Option C: Install a reduced-emissions outdoor wood boiler that meets EPA outdoor hydronic heater Phase 2 emissions limits with forced-air heat exchangers in the greenhouse to distribute the air. Based on independent testing, the boiler selected has an out-

Table 1: Average night heating requirement by month.

Month	Heating requirements, Btu per day	Approximate average hourly heating, Btu per hour
February	1,643,818	136,985
March	1,119,650	93,304
April	732,940	61,078
May	343,839	28,653

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put of 160,000 Btu per hour. The boiler would be placed on the side of the greenhouse and PEX tubing would be run into the house to two air exchangers placed in the center of the house. The air exchangers are placed one on each side of the center aisle facing in opposite directions to promote circular air flow. The heat exchanger fans and circulator pumps would be connected to a thermostat.

The installed cost is estimated to be $13,050 (boiler cost is $10,175, hot water to air heat exchangers are $1,600, piping and pumps are $775, labor and concrete pad cost $500. The average efficiency of this boiler is 75 percent based on EPA data. Heat loss from the boiler and piping to the greenhouse is not included nor is the amount of wood burned during the day when there is little or no demand.

Option D: This is the same as option C, but includes a non-qualifying outdoor wood boiler for EPA emissions reduction program (pre-2008 typical outdoor boiler). Estimated efficiency is 40 percent. Installed cost is $11,634 (boiler cost is $8,760). All other costs are the same.

Heating requirements

A heat balance model for auditing greenhouses was used to calculate the heating requirement to maintain set-point temperatures (Table 1). In a typical greenhouse, 80 percent of the heating occurs at night. In this case, the day-time heating needs are, on average, provided fully by solar radiation except during February. The average day-time heating requirement for February is 12,795 Btu per hour or about 10 percent of the overall daily heating requirement.

Table 2: Heating requirement based on outdoor temperature.

Outdoor temperature	Heating requirement (Btu per hour)
-20°F	244,600
-10°F	215,800
0°F	187,000
10°F	158,300
20°F	129,500
30°F	100,700
40°F	71,900

The model uses monthly weather data so it is an average of the heating requirements.

The usable heat from a stove or furnace was estimated by comparing the heat requirement and the stove or furnace output. There will be periods of low temperature swings when the stove or furnace doesn't have enough capacity to maintain set-point temperature. The thermostat for the current propane heater would be set

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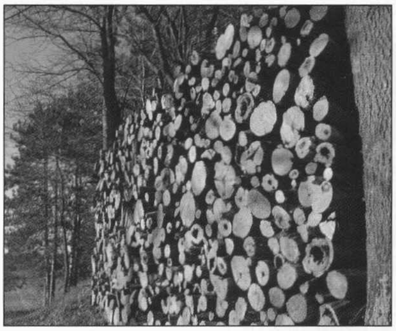


Before investing in a biomass heating system you should also compare energy efficiency options.

about 5°F below the set-point of the furnace thermostat so the propane heaters would provide supplemental heating during cold periods.

Greenhouse heaters are sized to maintain the set-point temperature at some minimum ambient air temperature. Table 2 shows the required heating capacity to maintain an inside temperature of 65°F. Based on the output capacity of heating systems used in this study, Option A can provide 100 percent of the heating requirement down to an outside temperature of 40°F while Options B, C and D should provide 100 percent of the heating requirement down to about 10°F.

The average minimum temperature for Madison, Wis., in February is 14.3°F so based on monthly heating averages, Options B, C and D should be able to provide 100 percent of the heating needs. In reality there will be many nights (and some days) when the heat loss will be higher than the capacity of the biomass heating system. It is estimated that propane heat will provide 20 percent of the heating for Options B, C and D to supplement the heating on nights colder than 10°F.

Expected energy replacement

The greenhouse heat loss model estimates the greenhouse will require 1,592 gallons of propane at a cost of $2 per gallon for an overall cost of $3,184 for the spring growing season. The cost of wood pellets locally is $4.60 per 40 pound bag in 50 bag pallet lots and $150 per cord of wood (assumed the cost of harvesting wood yourself). If a bulk storage bin was available, the wood pellet cost could be reduced to $178 per ton (20 ton load) and it would save on labor. Table 3 summarizes the energy costs and savings for the different options.

Best option

The pellet burners have a better return on investment than the cord wood boilers even though the energy cost for Option C is lower. Both pellet stoves have longer paybacks than may be acceptable.

The lower-emission, higher-efficiency outdoor wood boiler is a better investment than the standard outdoor boiler, but both have a longer payback than would be acceptable by most businesses. The longer payback is due to the higher capital cost without a corresponding increase in energy savings. The payback is very sensitive to the spread of the difference between propane and wood pellet costs.

Last winter when wood pellets were selling for $4 per 40-pound bag and propane was selling at $2.15 per gallon, the payback for Options A, B, C and D were 4.7, 4.6, 7.1 and 9.4 years, respectively. Investing in energy conservation projects would be a better investment.

Final considerations

A word of caution -- the analysis for this greenhouse case study doesn't take into account ash disposal costs, mainte-

Table 3: Summary of biomass heating options

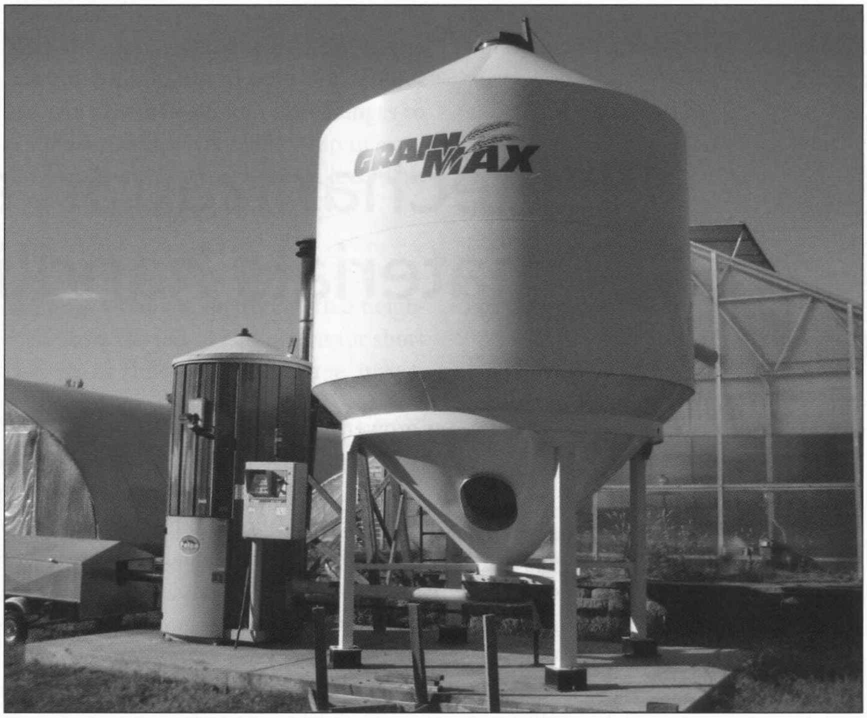
Heating system	System cost	Biomass quantity	Biomass energy cost	Propane (gallons)	Propane cost	Total savings	Simple payback (years)
Option A: residential pellet stove	$4,350	282 40-lb. bags	$1,297	639	$1,278	$609	7.1
Option B: pellet furnace	$6,030	355 40-lb. bags	$1,633	318	$636	$915	6.6
Option C: outdoor wood boiler (EPA certified)	$13,050	6 cords	$900	318	$636	$1,648	7.9
Option D: outdoor wood boiler	$11,634	10 cords	$1,500	318	$636	$1,048	11.1

nance and repair costs and daily management and labor. A net present value analysis is recommended to account for these costs.

Long term energy prices are expected to continue to rise, so investing in biomass energy should be a good investment providing biomass is readily available in your local area.

This article only made comparisons between different types of biomass heating systems. Compare energy efficiency options such as double wall glazing, higher efficiency heating systems and thermal energy curtains to make sure you are receiving the highest return on investment. Investing in energy efficiency first reduces the size of a future biomass-fueled heating system.

Scott A. Sanford is senior outreach specialist, University of Wisconsin-Madison, Biological Systems Engineering; (608) 262-5062; sasanford@wisc.edu; www.bse.wisc.edu; www.uwex.edu/energy



Commercial sized pellet boilers and bulk storage bins for pellets are an option for replacing traditional fuel such as propane.